

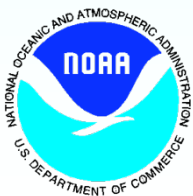
Flooding in Western Washington: The Connection to Atmospheric Rivers

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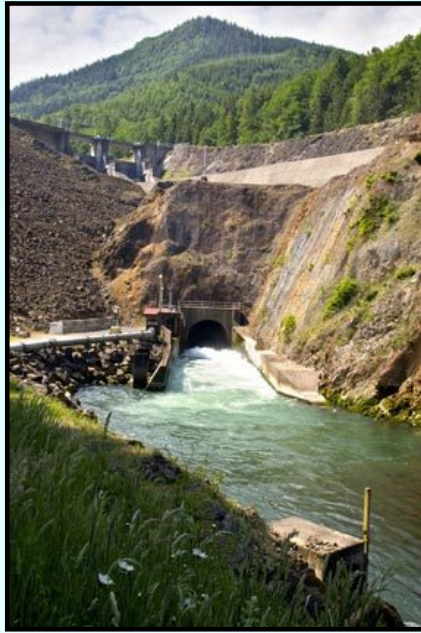
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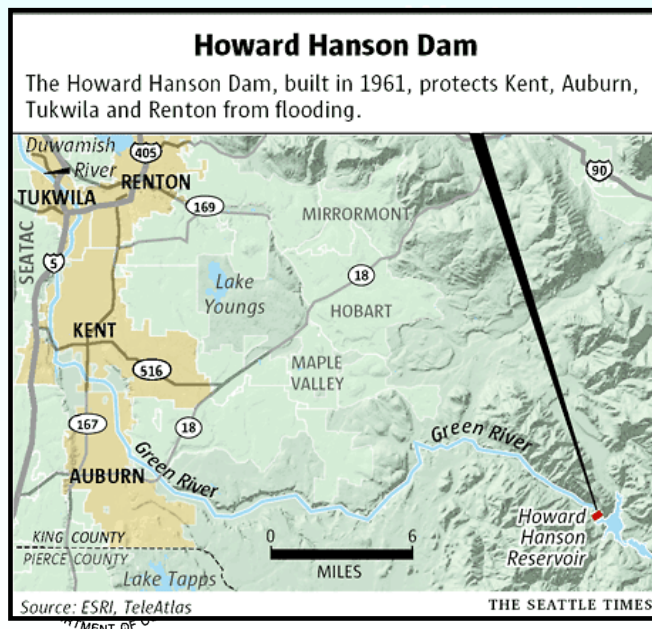
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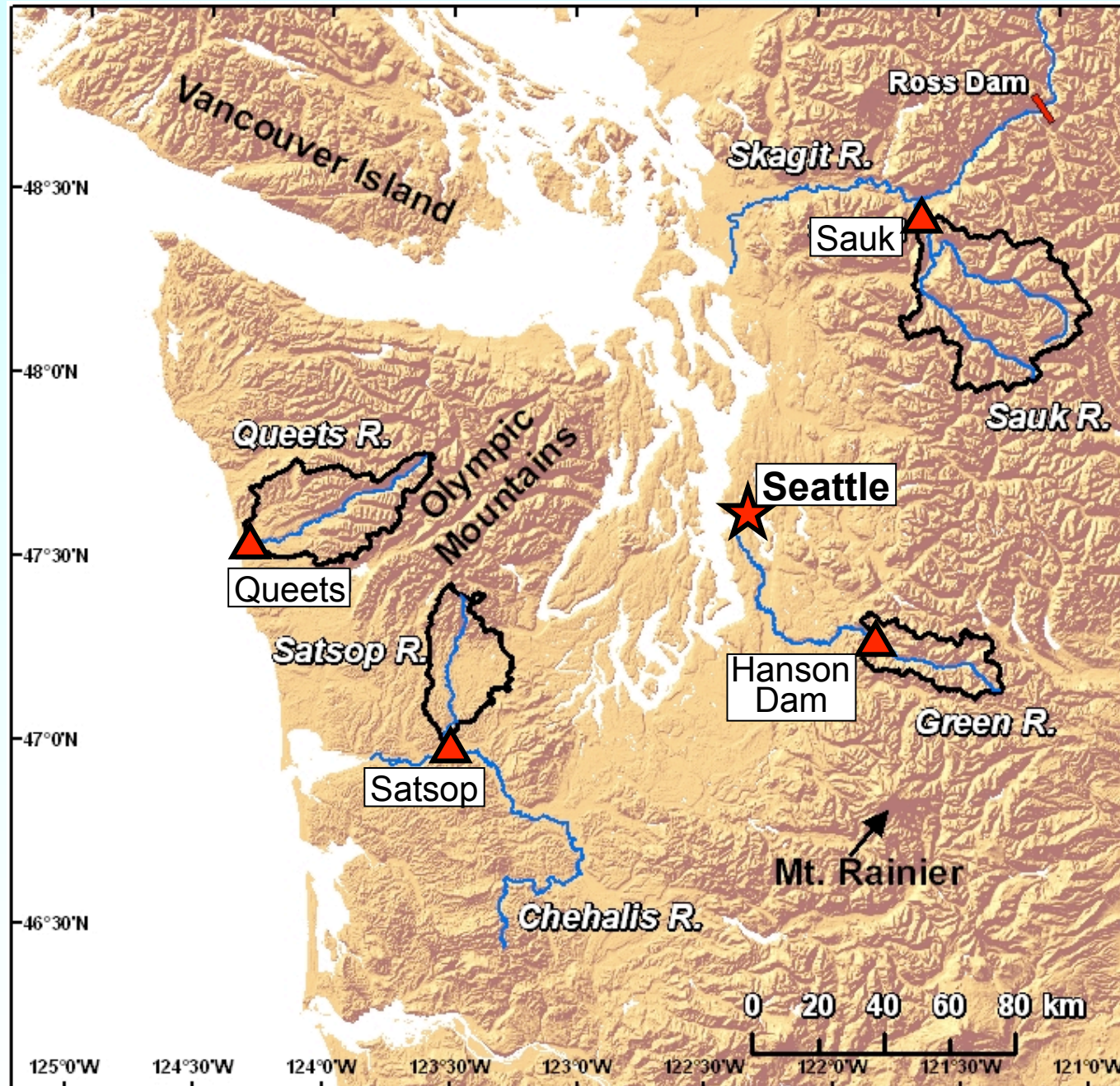




Motivation

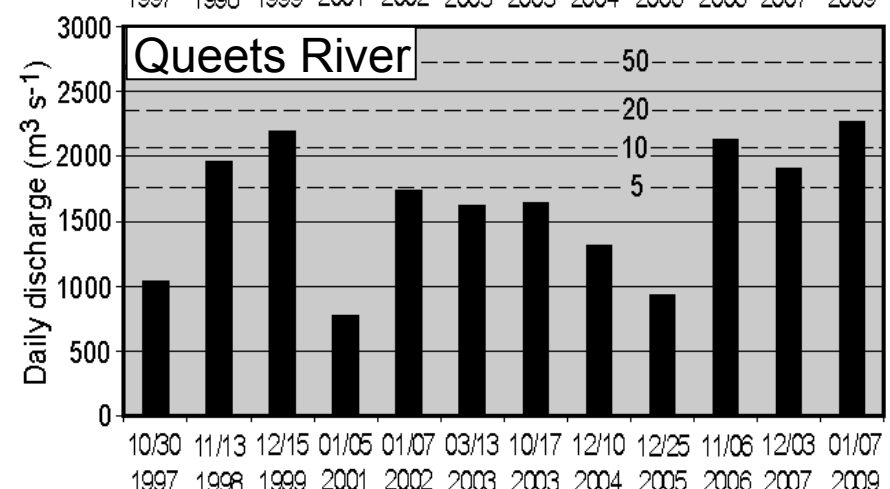
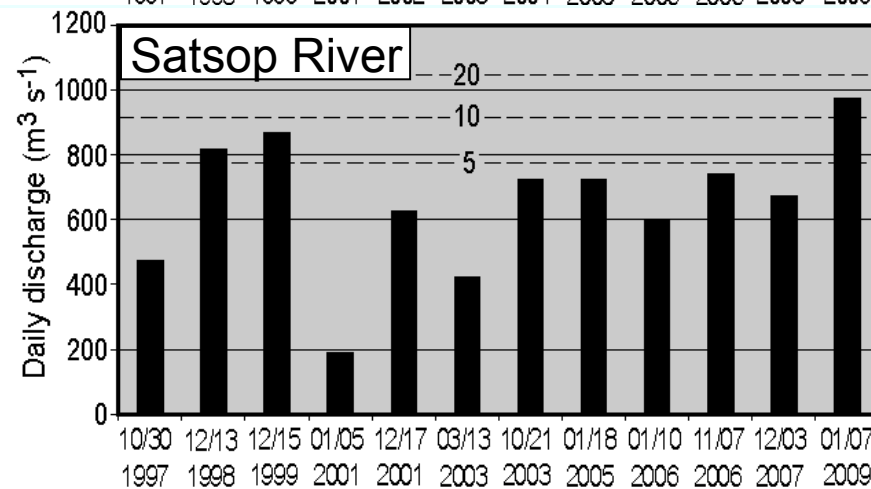
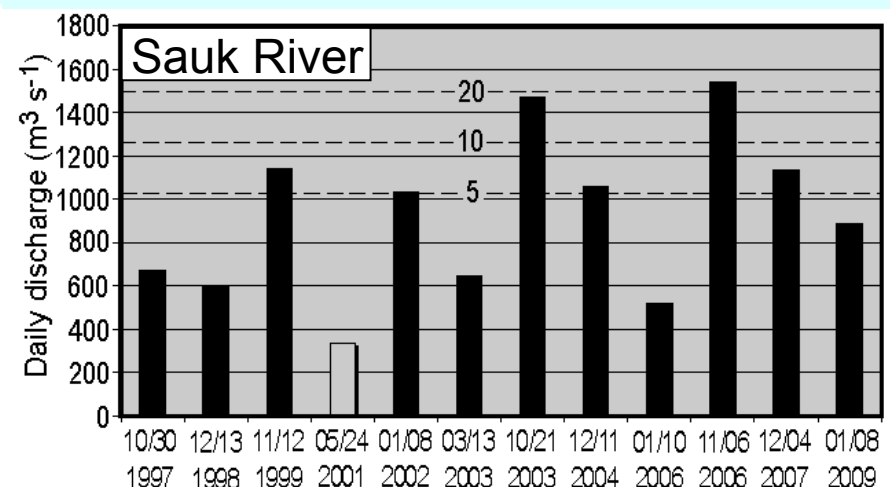
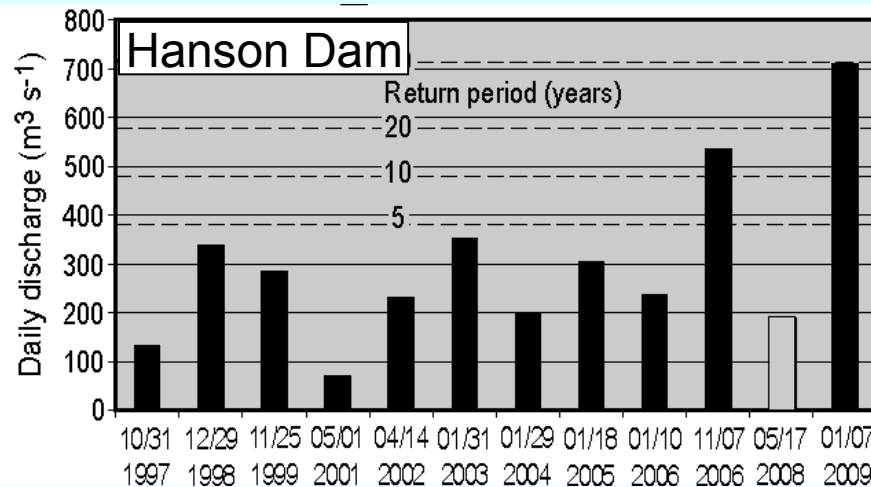
- Dedicated in 1962, the Howard A. Hanson Dam (HHD) brought necessary flood relief to Seattle's Green River Valley and opened the way for increased valley development.
- The valley is now home to nearly a half million people and multi-billion dollar industries.
- Following a record high level of water behind HHD in Jan. 2009, the U.S. Army Corps of Engineers became concerned about damage sustained by the Dam during that flood, and the safety of those downstream.
- Partly in response to the dam's compromised state, NOAA's PSD and the Army Corp teamed up to research causes of flooding on four watersheds in the complex terrain of western WA.





Annual peak daily flows (APDFs) and atmospheric river (AR) events for WY1998-2009

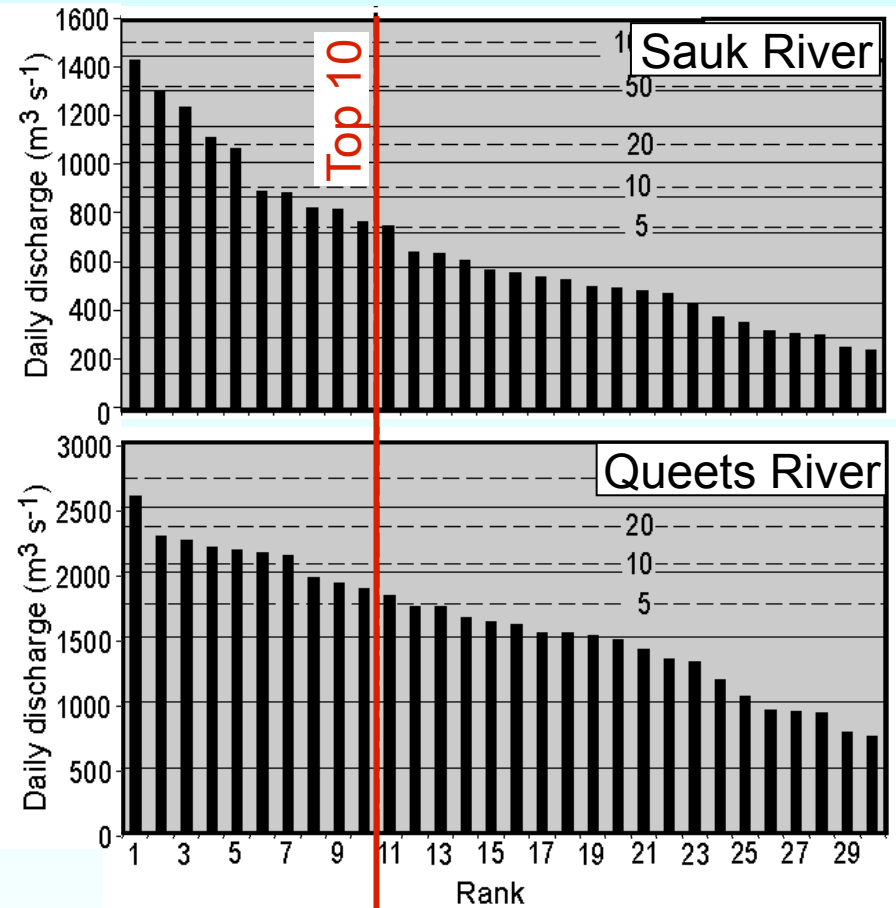
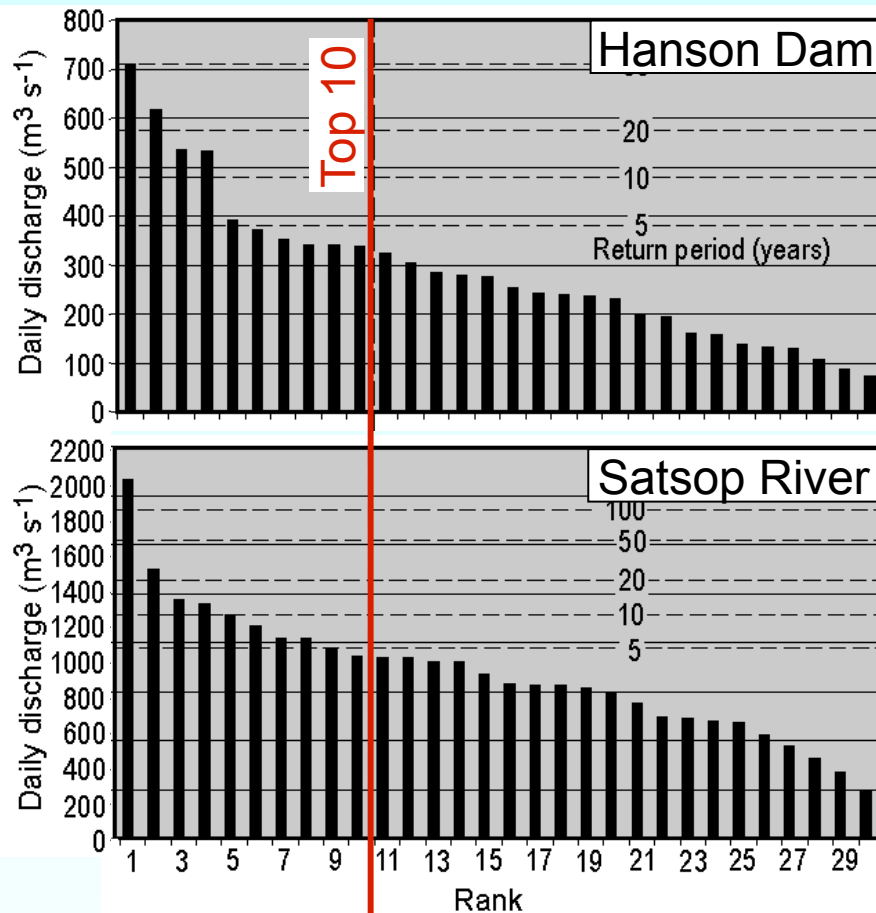
■ AR ■ non-AR [determined from 2x-daily SSM/I IWV satellite imagery]



Peak water year flow date

46 of 48 annual peak daily flows in last 12 years at the 4 sites due to AR landfalls

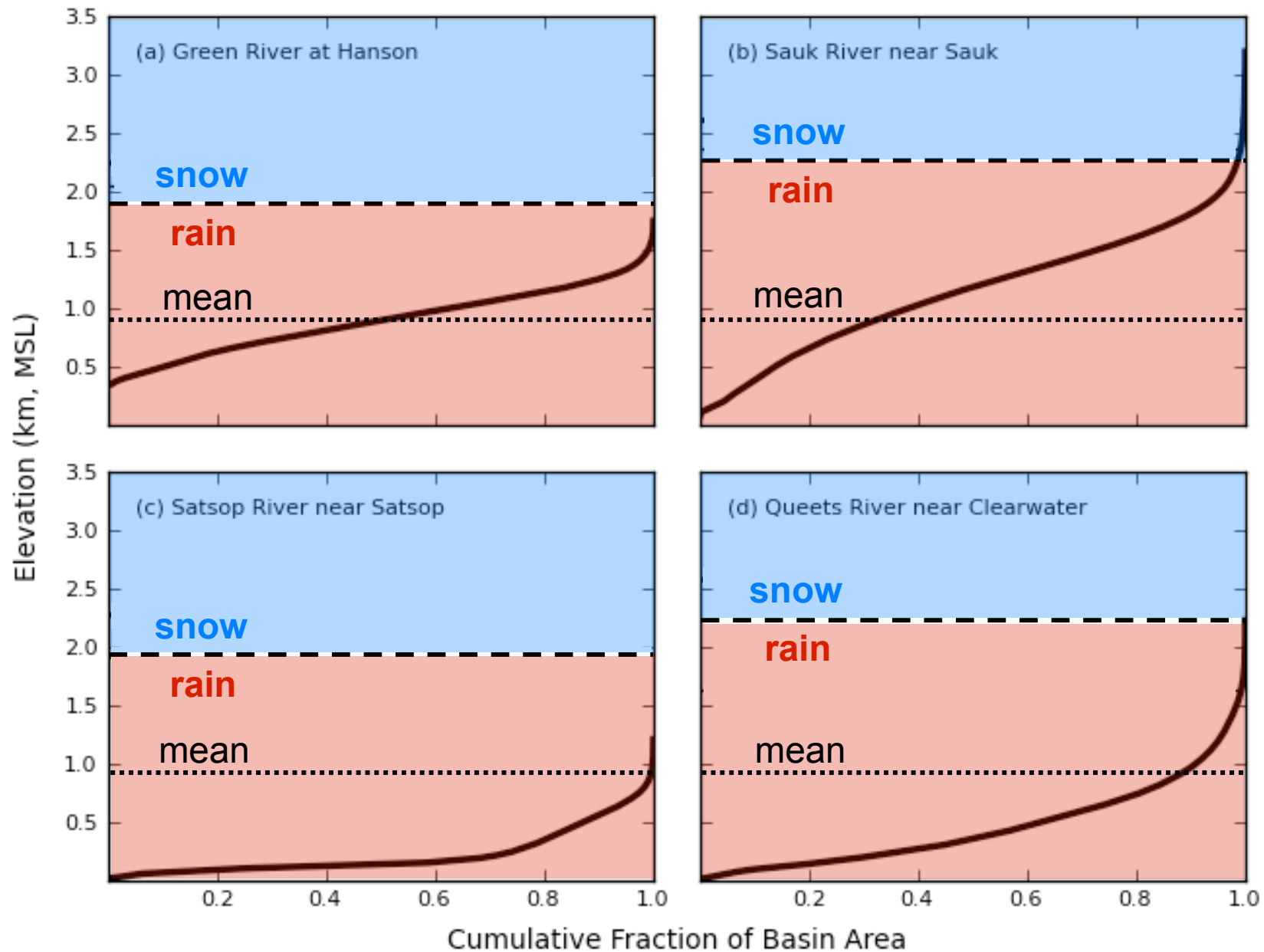
Ranked APDFs for WY1980-2009 (NARR period)



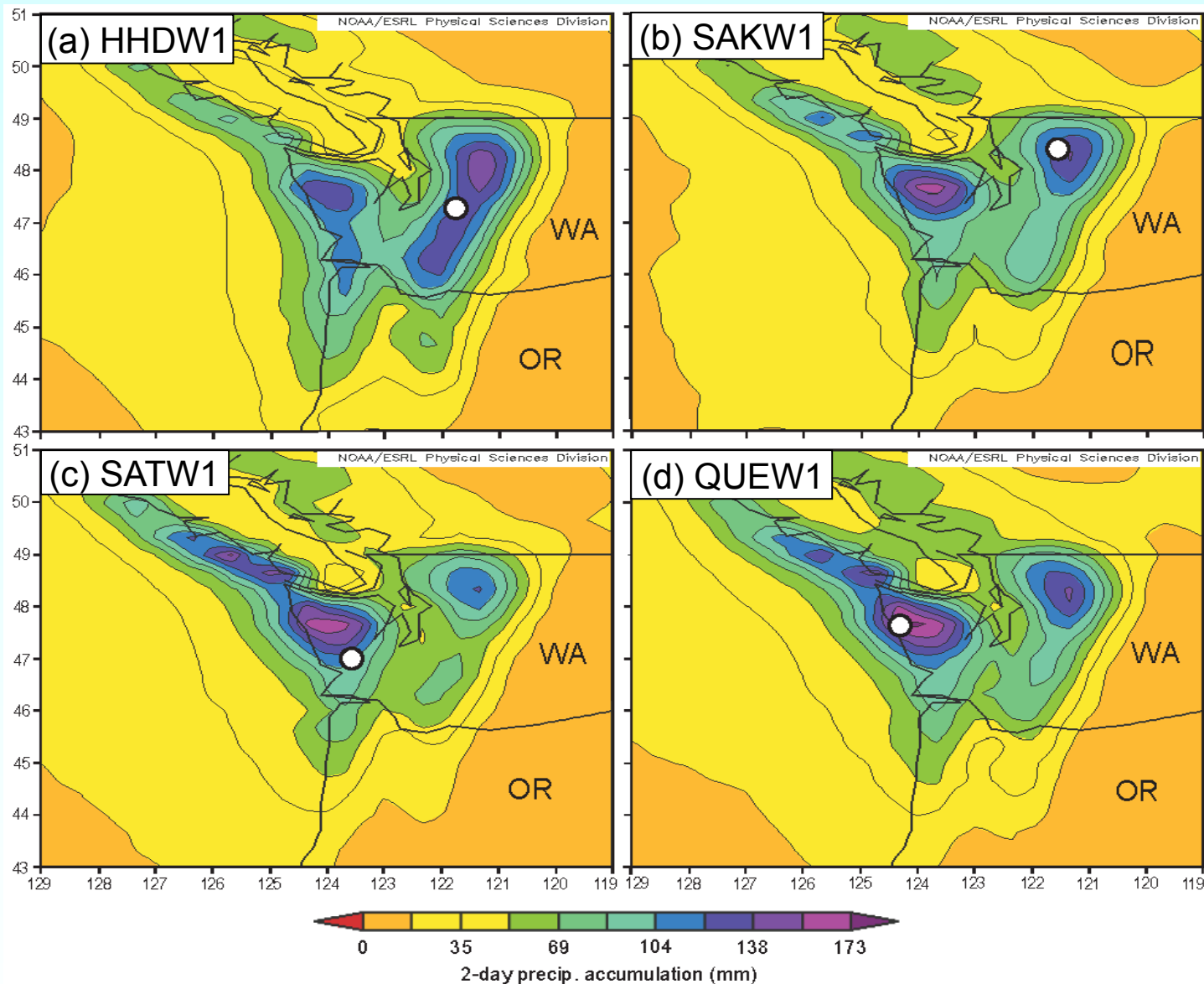
The APDFs occur most often Nov. - Jan.

Dates from the top-10 APDFs are used to create composite analyses from the North American Regional Reanalysis (NARR) to assess the composite meteorological conditions most likely to produce flooding in each of the four basins

Basin altitude attributes above gauges, and mean NARR top-10 melting-level altitudes*
*(300 m below 0°C altitude)

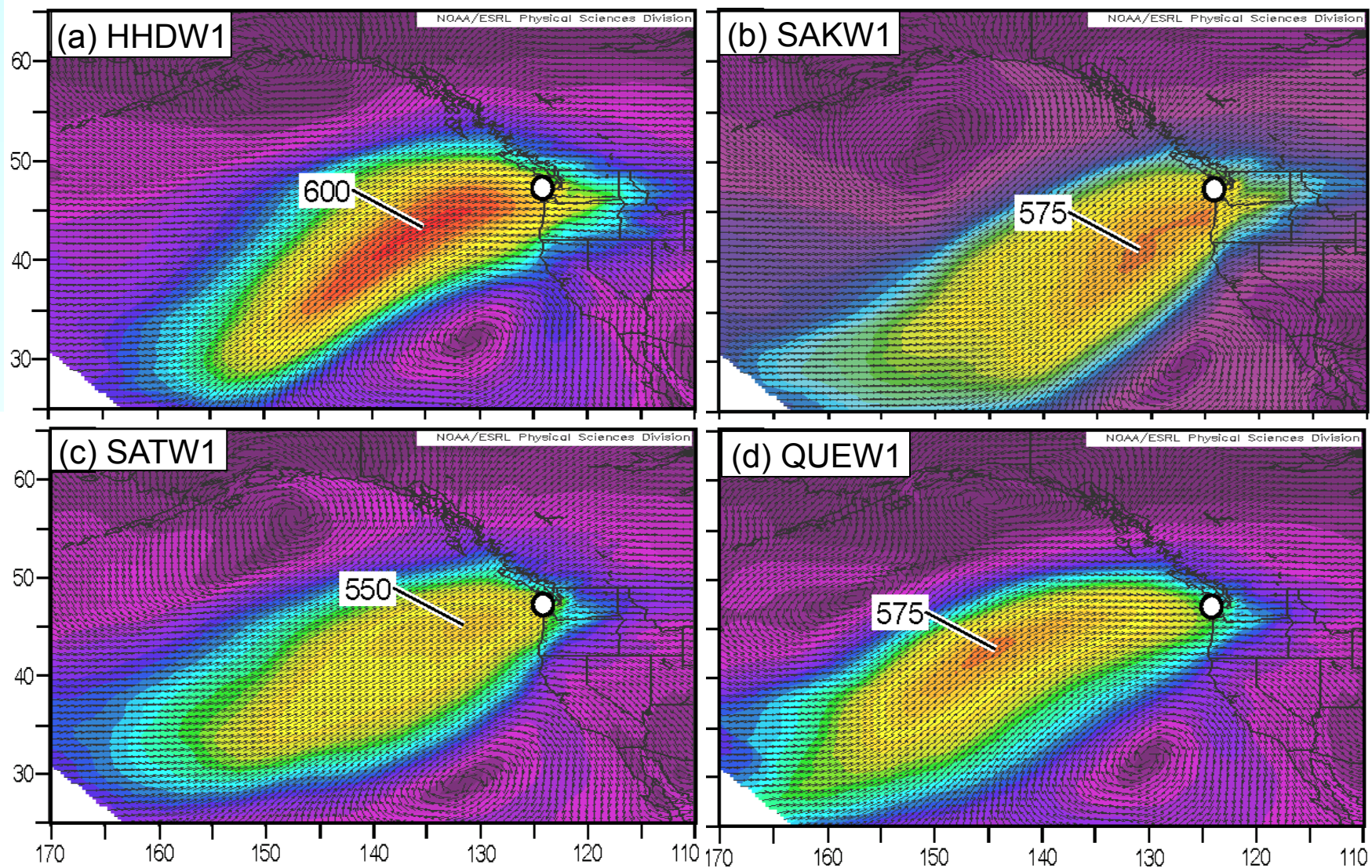


NARR Reanalysis Composite Mean 2-day Precipitation (mm)

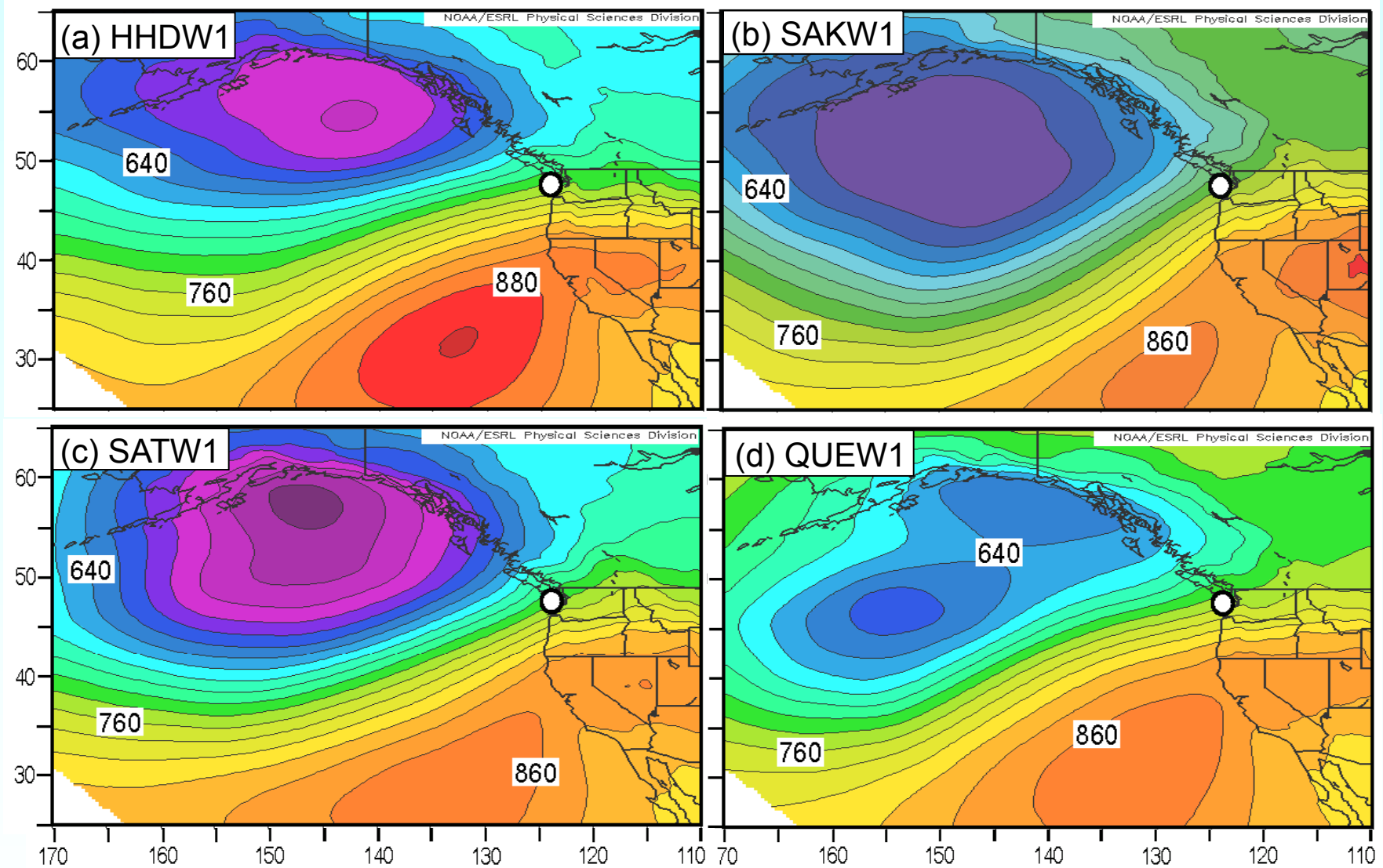


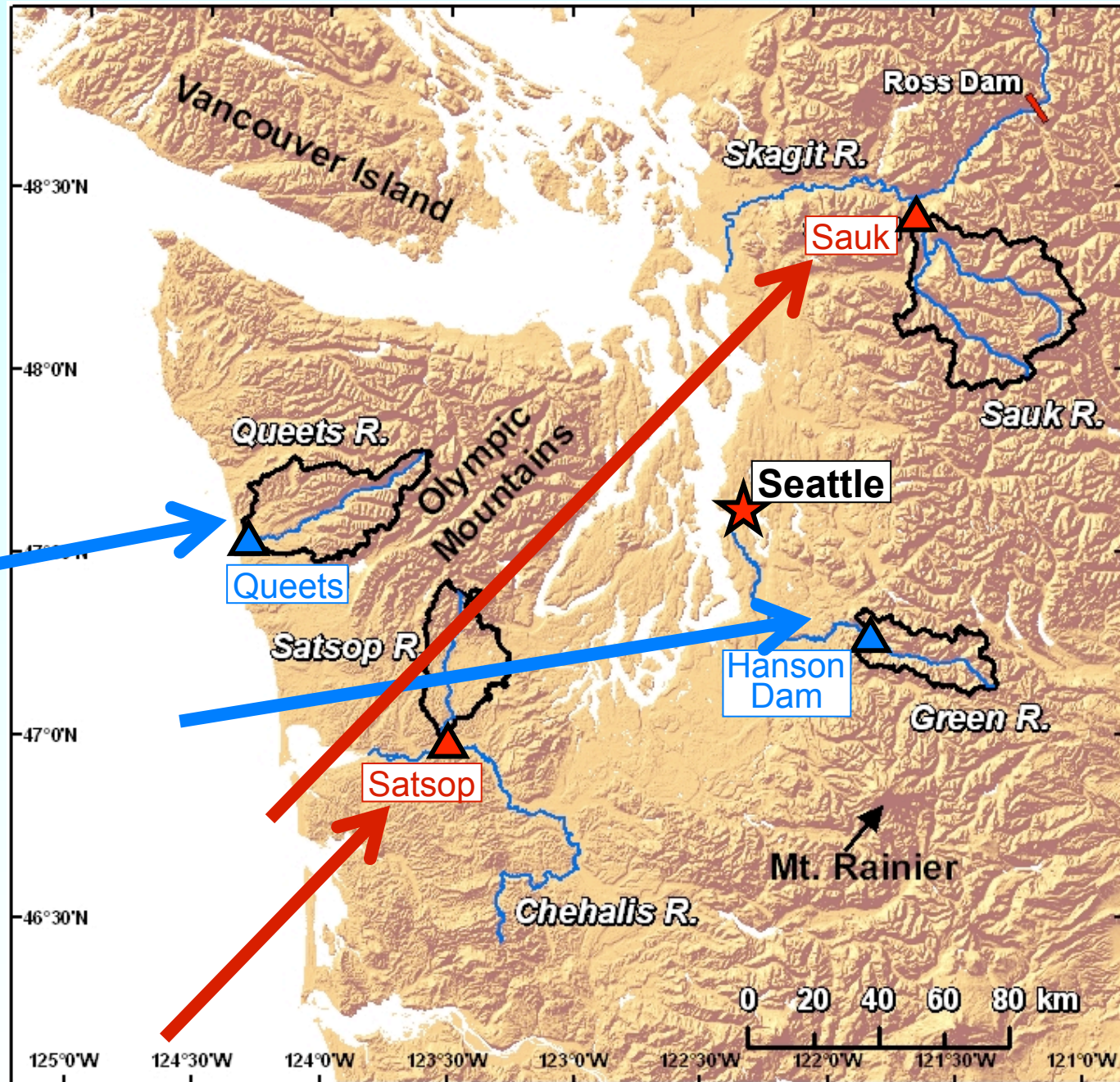
Anomalously high melting levels + heavy precip = floods

NARR Reanalysis Composite Mean Integrated Vapor Transports ($\text{kg s}^{-1} \text{ m}^{-1}$)

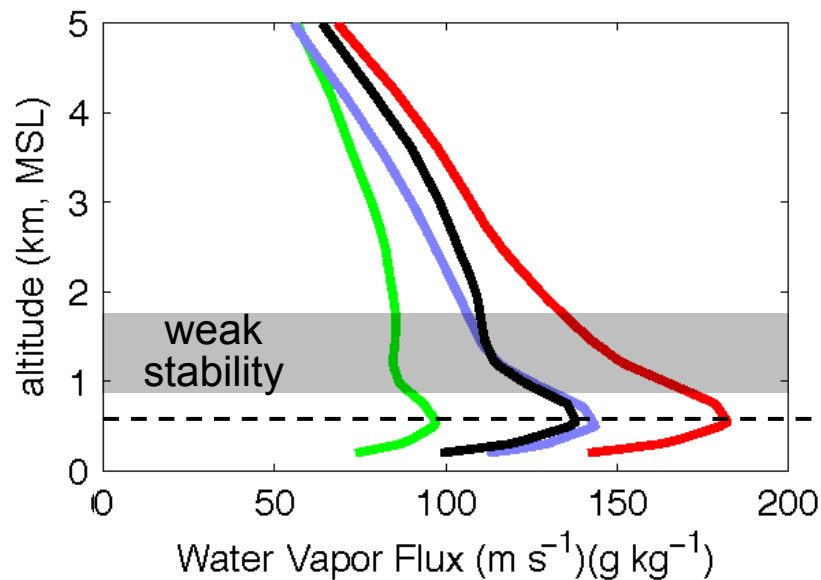
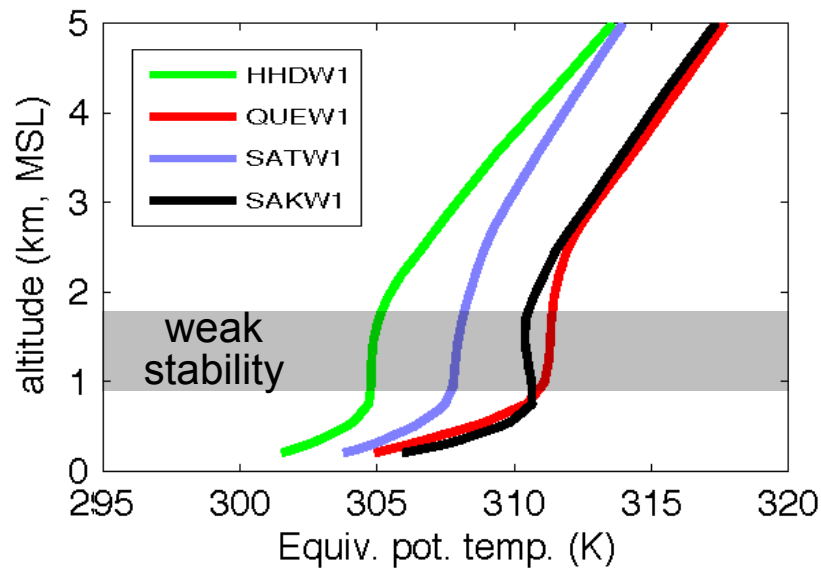


NARR Reanalysis Composite Mean Geopotential Heights (m) at 925 hPa





NARR Reanalysis Composite Mean profiles at coast



Max. orographic forcing
in AR conditions at
coast. Minimal terrain
lift would place it in
weakest stability –
optimal for heavy precip!



Conclusions

- Multiple decades of daily streamflow data from four major watersheds in western Washington were used to determine the meteorological conditions most likely to cause flooding in those watersheds.
- The combination of SSM/I IWV satellite imagery and streamflow data highlight a nearly 1:1 link between each year's largest daily flow and landfalling ARs.
- Based on the NARR, the largest annual streamflows occur during landfalling ARs with low stability, anomalously high melting levels, and strong onshore vapor fluxes: all conducive to orographically enhanced synoptic precipitation.
- Given the highly 3-D character of the terrain, flooding in two of the basins occurred during mean southwesterly flow and the other two occurred during nearly zonal flow.



Thank you!



Mt. Rainier, van Trump Park
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